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Invitation to the 12th Workshop on GHG Inventories in Asia (WGIA12)
- Capacity building for measurability, reportability and verifiability –
August 4 - 6, 2014,

Estimation of Carbon Flux and Stock in tropical peatland applying Integrated MRV System

Mitsuru Osaki
Research Faculty of Agriculture, Hokkaido University

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What is high-carbon reservoirs?

UNFCC-SBSTA 38 Research Dialogue
-Developments in research activities relevant to the needs of the Convention-
4 June 2012, 15:00 - 18:00, Maritim Hotel, Bonn, Germany

Plenary II: Emerging scientific findings: Ecosystems and GHG emissions and removals from sources, sinks and reservoirs, including from terrestrial ecosystems

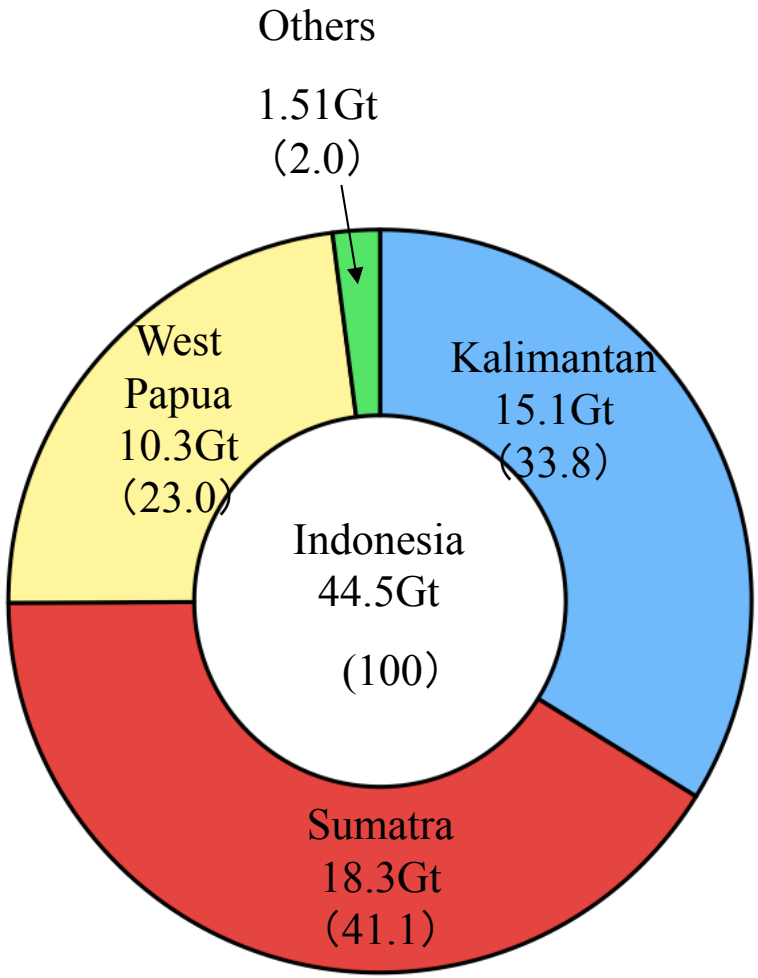
United Nations
Climate Change Secretariat

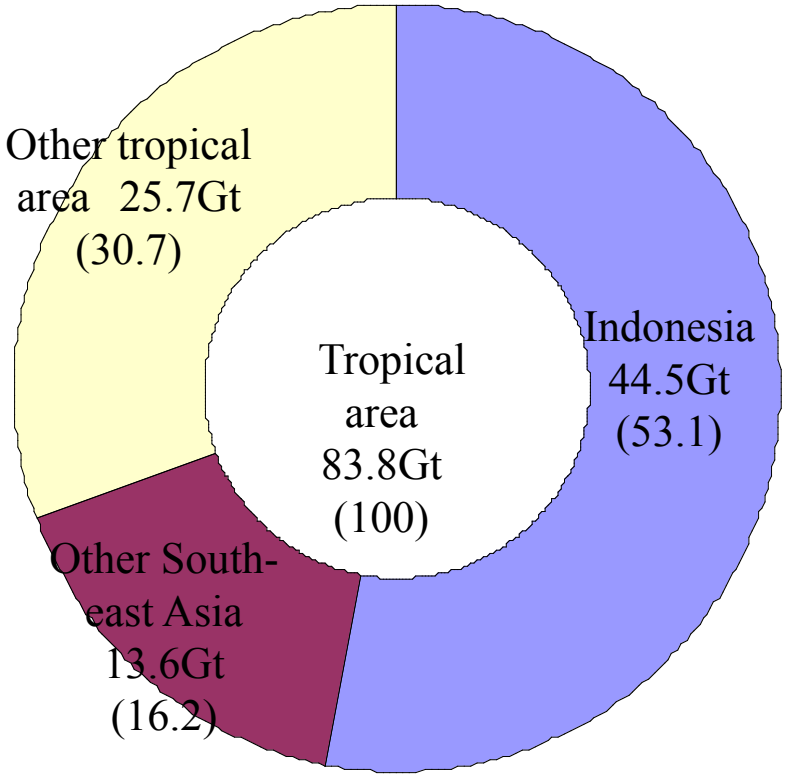
UNFCCC workshop on "Technical and scientific aspects of ecosystems with high-carbon reservoirs not covered by other agenda items under the Convention"

24 to 25 October 2013, Bonn, Germany

1) Peatlands/Wetlands
2) Costal Ecosystem (Mangrove/Coral/Sea grass/Wetlands)
3) Permafrost

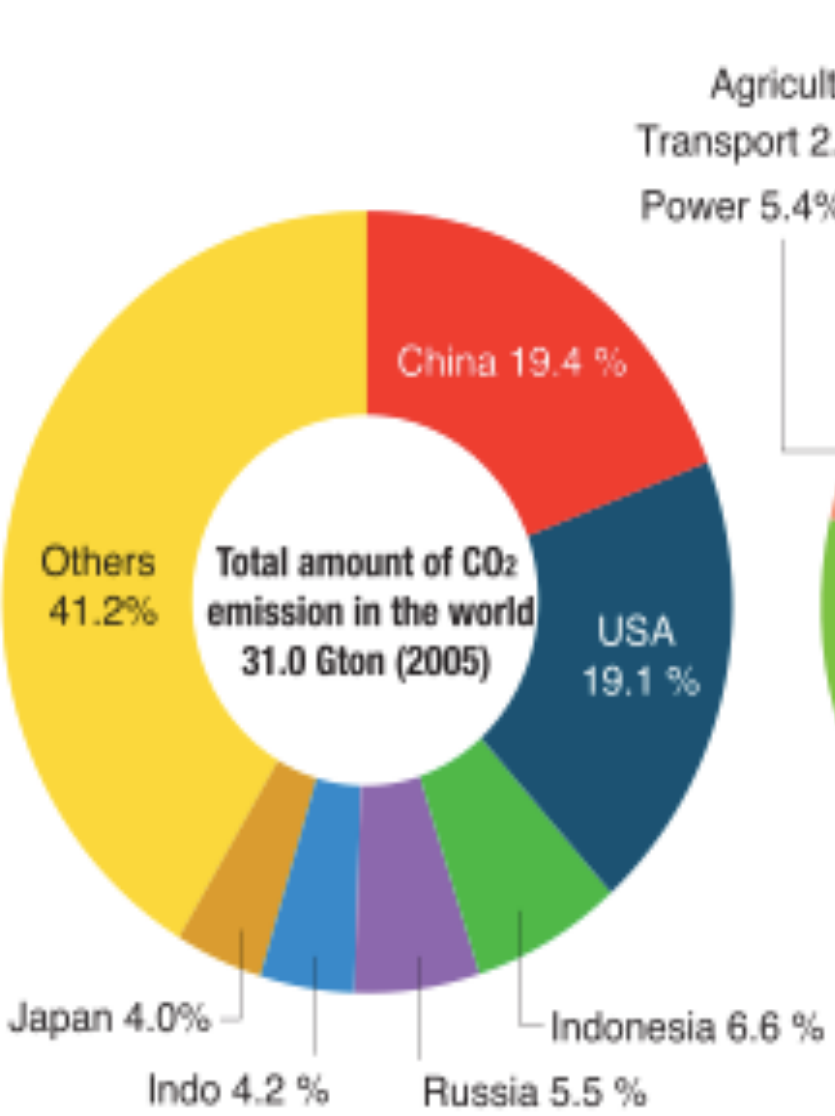
Amount of Carbon in Tropical Peat (GtC (%))



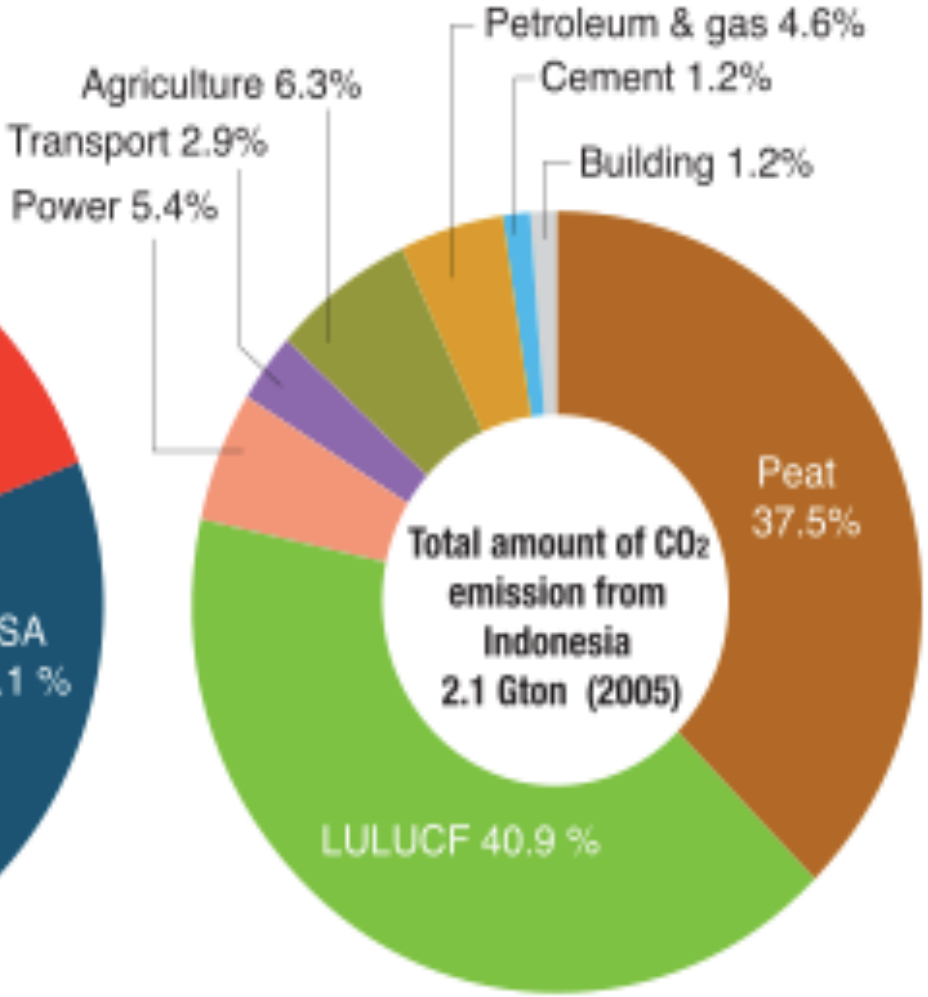


(From Maria Strack ed., 2008: Peatlands and Climate Change. International Peat Society, 223pp.)

Total amount of CO_2 emission



Source: http://www.eia.doe.gov/iea/carbon.html



Source: Indoneisa's green house gas abatement cost curve (DNPI, 2010)

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How to estimate High-carbon reservoirs ecosystem?

Contribution to IPCC Wetlands Guideline

2013 SUPPLEMENT TO THE 2006 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES: WETLANDS

Methodological Guidance on Organic and Wet Soils across IPCC Land-use Categories

Lead-Authors of CHAPTER 1

Coordinating Lead Authors
Tom Wirth (USA) and Chengyi Zhang (China)

Lead Authors
Gusti Zakaria Anshari (Indonesia), Kenneth Byrne (Ireland), Elke Hodson (Switzerland), Hans Joosten (EC/WI/FAO), J. Boone Kauffman (IUCN/UNESCO), Leif Klemedtsson (Sweden), Tuija Elina Lapvetelainen (Finland), Christoph Mueller (Germany), Phillip O'Brien (Ireland) and Mitsuru Osaki (Japan)

Still TIER 1 level

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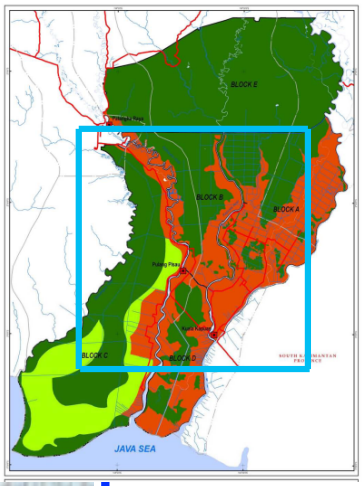
Three methodological Tiers

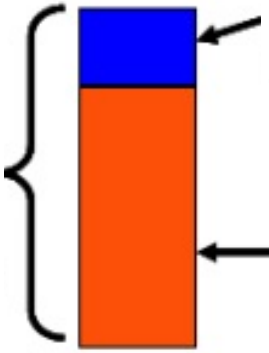
- IPCC Guidelines provide **three methodological tiers** varying in complexity to be chosen on the basis of national circumstances
- **Tier1** :
  - **Simple first order approach**
  - spatially coarse default data based on globally available data
  - large uncertainties
  - methods involving several simplifying assumptions.
  - default values of the parameters from the IPCC guidelines
- **Tier 2**:
  - **A more accurate approach**
  - country or region specific values for the general defaults
  - more disaggregated activity data
  - relatively smaller uncertainties
- **Tier 3**:
  - **Higher order methods**
  - detailed modeling and/or inventory measurement systems
  - data at a greater resolution
  - lower uncertainties than the previous two methods
- **Higher Tier methods (Tier 2&3)**are required for **key source categories**, source or sink categories that contribute substantially to the overall national inventory level, trend or uncertainty
- Higher tier methods will likely be used for REDD estimates especially for significant pools

COP15 at Copenhagen in 2009



COP15 Poster

Amount of carbon dioxide emitted annually from the tropical peatland per 1 million ha.
(Indonesia has 20 times the size of this tropical peatland.)



About 13% of the total emission from Japan in 1990.

Amount of carbon dioxide emitted by microbial degradation (About 3 % of the total emission from Japan in 1990.)

Amount of carbon dioxide emitted by peat fire (About 10 % of the total emission from Japan in 1990.)

Copenhagen Accord
- REDD+
- MRV: Monitoring-Sensing

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What is MRV for High-carbon reservoirs ecosystems?

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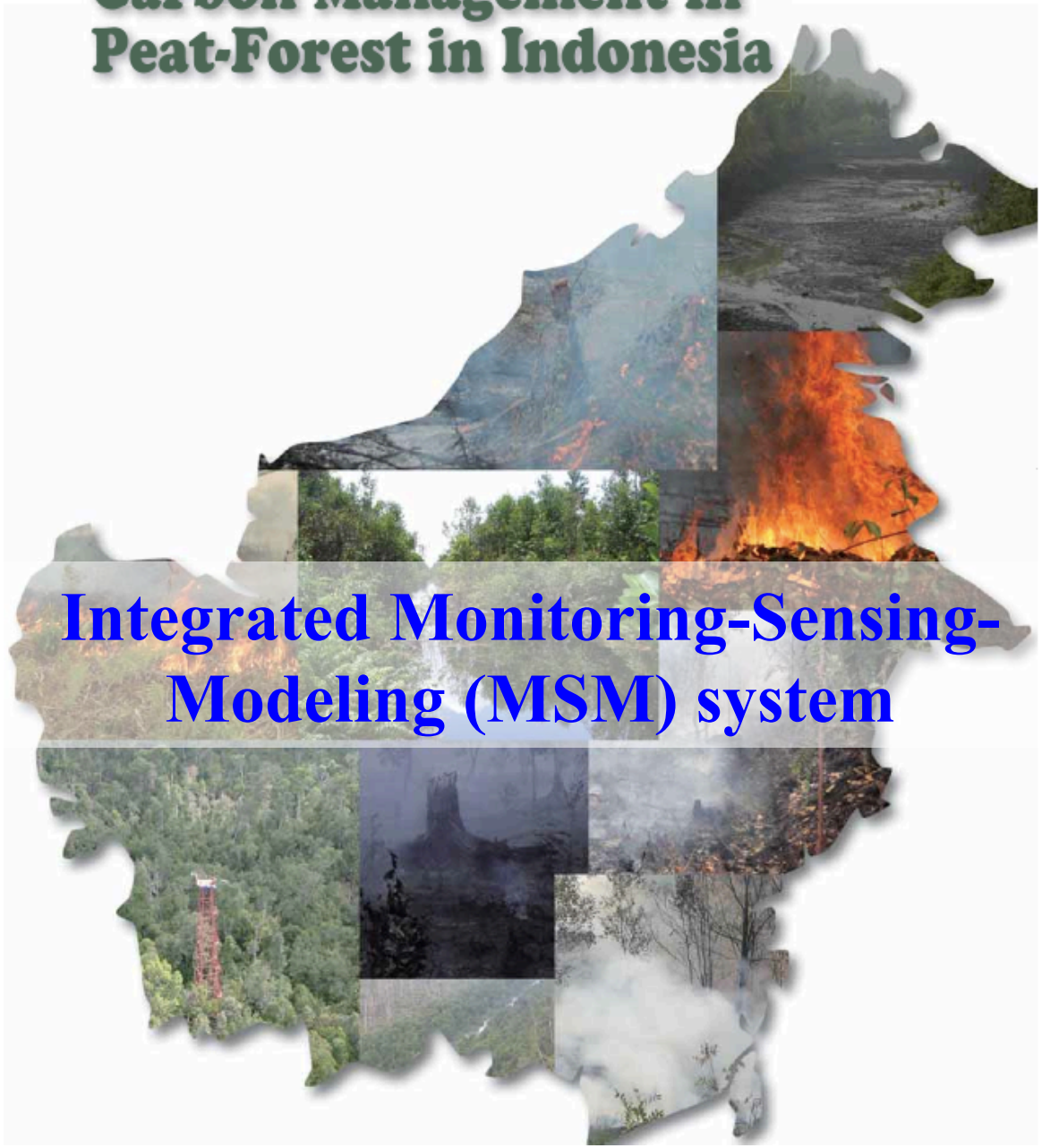
JST-JICA project on "Science and technology Research Partnership for Sustainable Development"

Wild Fire and Carbon Management in Peat-Forest in Indonesia



Integrated Monitoring-Sensing-Modeling (MSM) system

Main Project Sites

→Monitoring was started from 1997

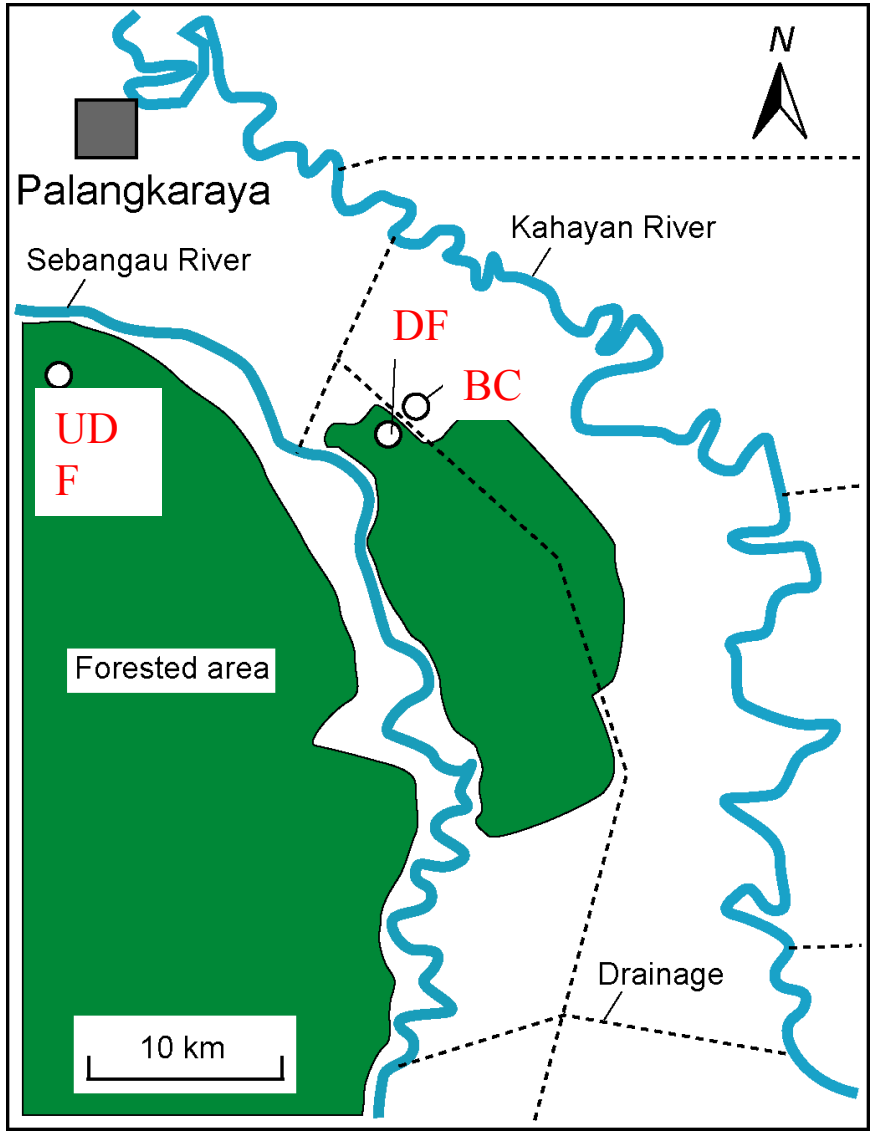
- Central Kalimantan, Indonesia
- Peatland area in Mega Rice Project site

CO_2 observation towers at

UDF : (Un-drained Peat)

DF : (Drained Peat)

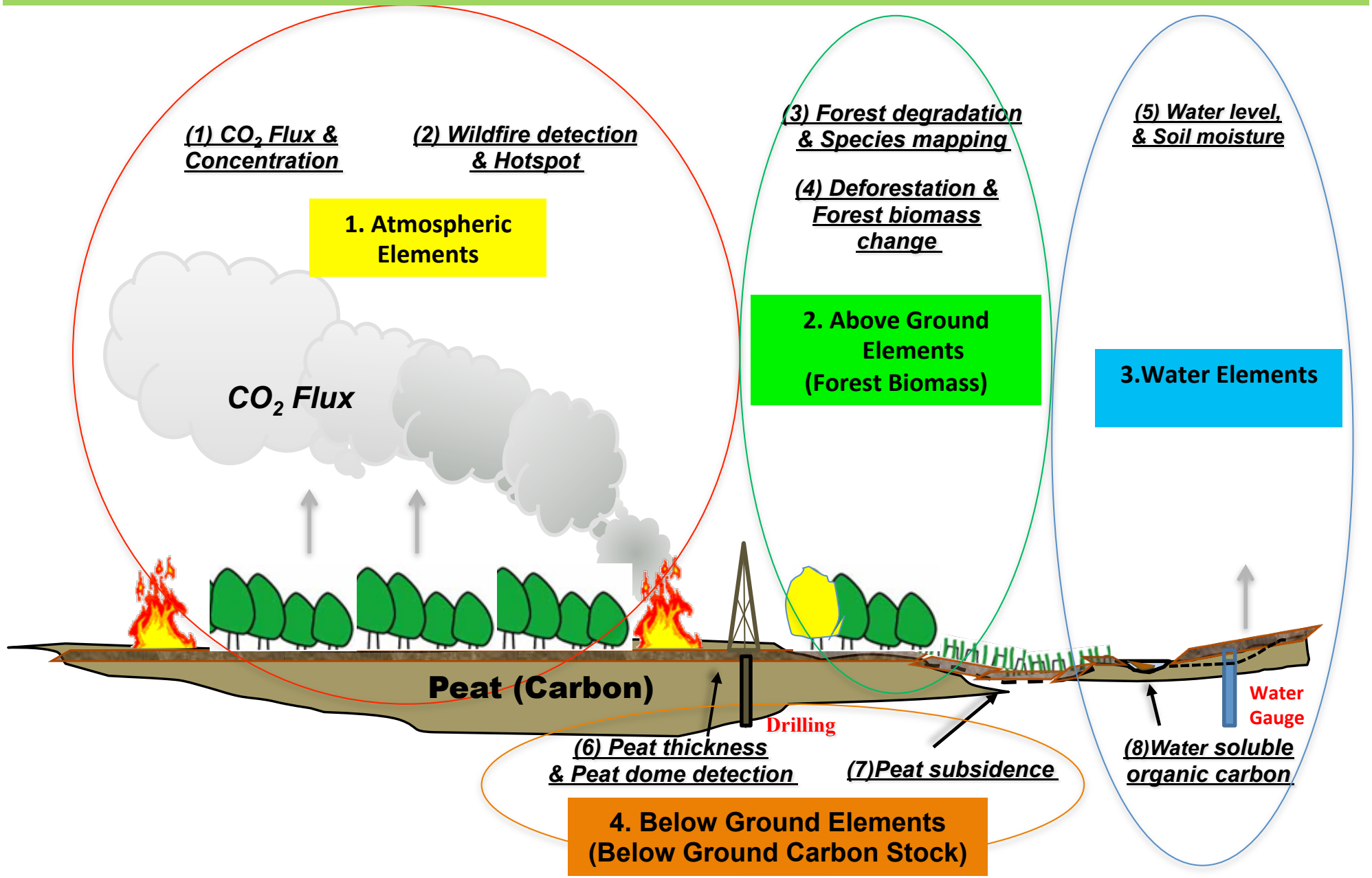
BC : (Burnet Peat)

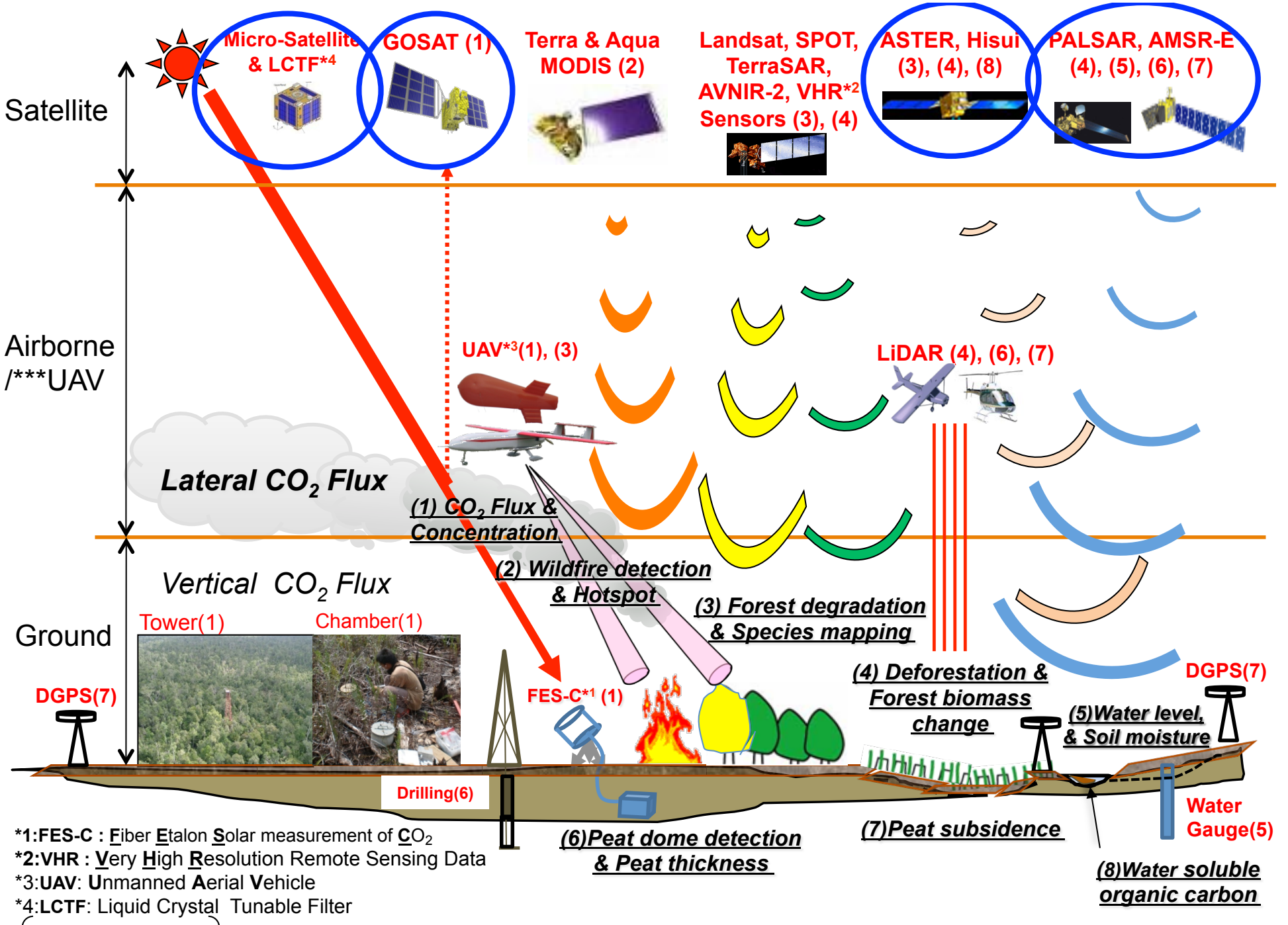


Various Study Topics:

- GHG Flux (CO_2, CH_4, N_2O) measuring
- Fire Detection and Protection
- Water Table Monitoring and Management
- Peatland Ecology
- Soluble Carbon Monitoring
- Peatland Subsidence Monitoring
- etc.

Key elements for integrated Monitoring-Sensing-Modeling (MSM) system of Carbon in peatland





*1:**FES-C** : **F**iber **E**talon **S**olar measurement of CO_2
*2:**VHR** : **V**ery **H**igh **R**esolution Remote Sensing Data
*3:**UAV**: **U**nmanned **A**erial **V**ehicle
*4:**LCTF**: Liquid Crystal Tunable Filter

Red: Instrument
Black: Target

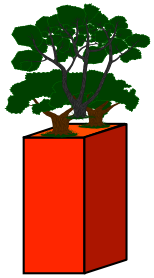
Key Elements of Tropical Peatland MSM System

Integrated Monitoring-Sensing-Modeling (MSM) system:

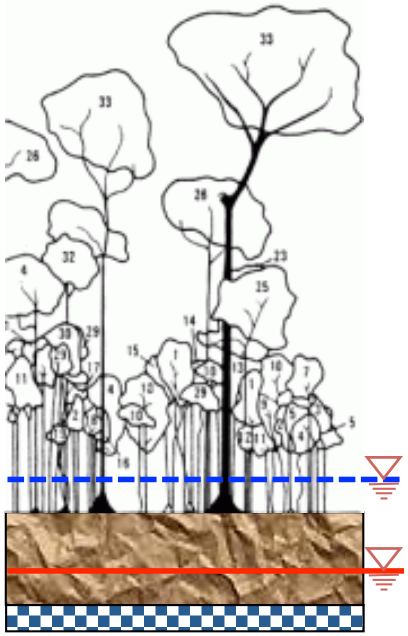
Carbon Stock

Photo from Erianto Indra Putra (UNPAR)

Peat Thickness Estimation (Shimada Model)



Shallow peat layer



Mineral Soil

Vegetation

(Physiology)

Adjust

Response

(cf. Lugo et al. 1990)

Phenology

Classification

Hydroperiod

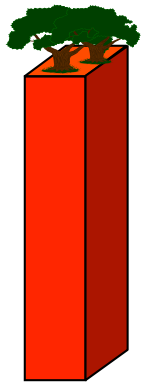
WET

DRY

Greater GWL fluctuation

Temporarily High flood condition

Hypothesis



Deep peat layer

Mineral Soil

WET

DRY

Moderate GWL fluctuation

Permanently Wet condition

Seasonal fluctuation of GWL is different; moderate at deep peat, while greater at shallow peat.

This might reflect the vegetation physiologically.

Idea of Peat Depth Classification

In Tropical Peat Swamp Forest, type of forest stand and its phenology are corresponded to Peat Depth, in terms of seasonal groundwater level fluctuations.

Its difference produce

spatial trends of plant activity in each season.

To detect these,

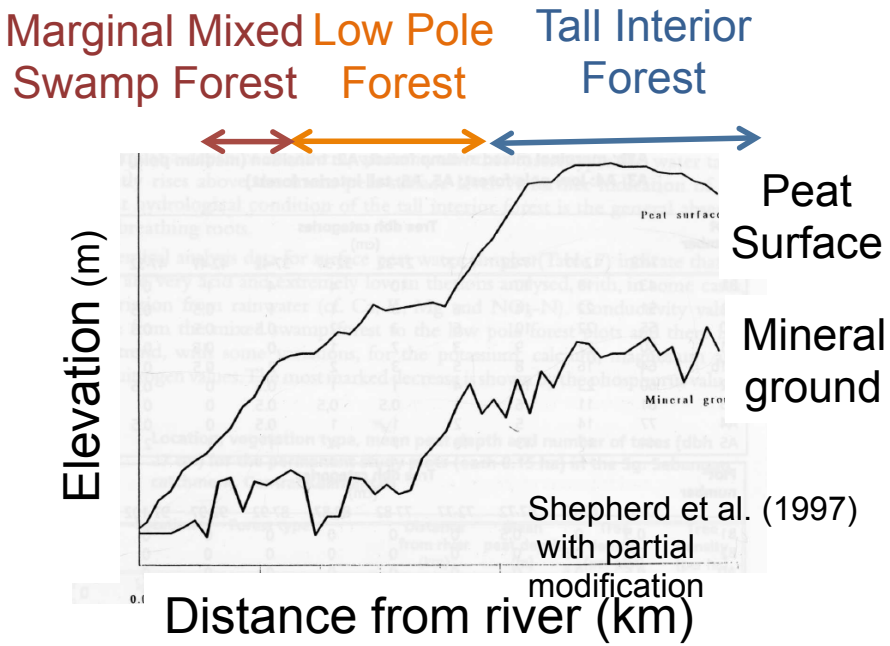
Supervised classification were conducted using **multi-temporal satellite scene** with **Peat Depth Database as training data**.

Index of Plant Activity: **NDVI**

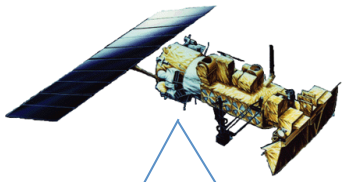
Target Period : **Early 90's**

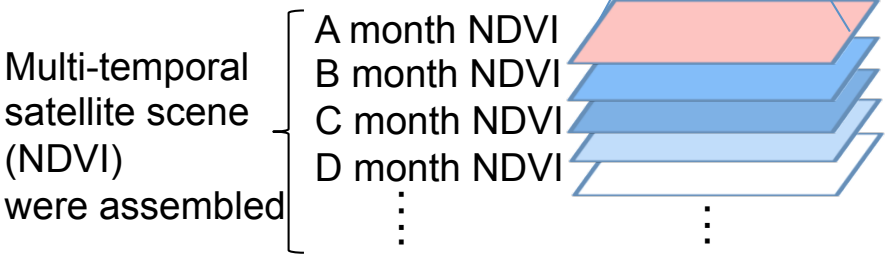
Relatively Undisturbed Condition

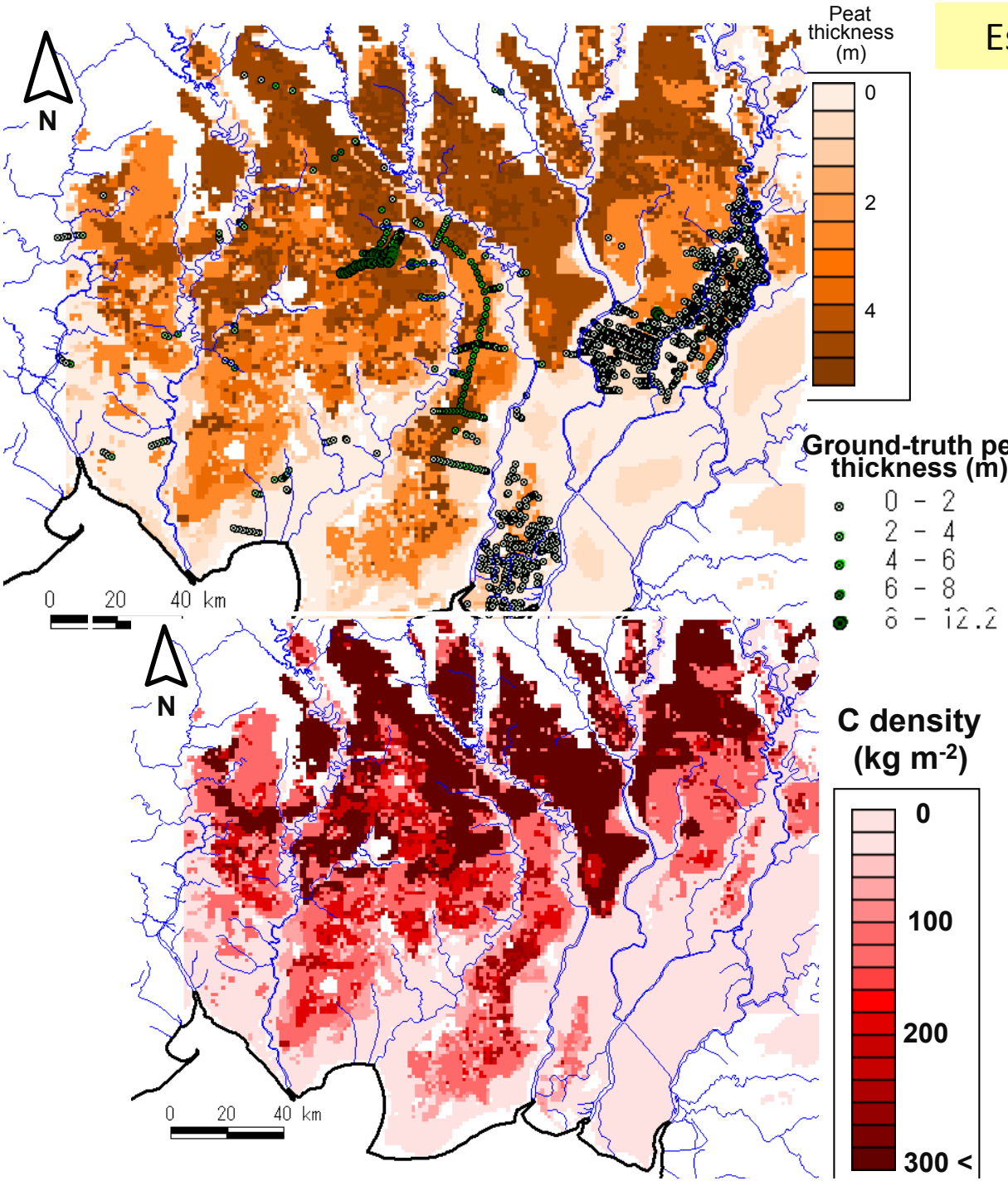
(Before Mega Rice Project)



$$NDVI = \frac{NIR - Red}{NIR + Red}$$







Estimated Map of Peat Thickness

Root Mean Square Error (RMSE)

= 1.64 m

×

Distribution Map of C-density (Shimada et al. 2001)

3.1 Mha

C-pool

= 4.2 Gt

1.4 Gt Mha^{-1}

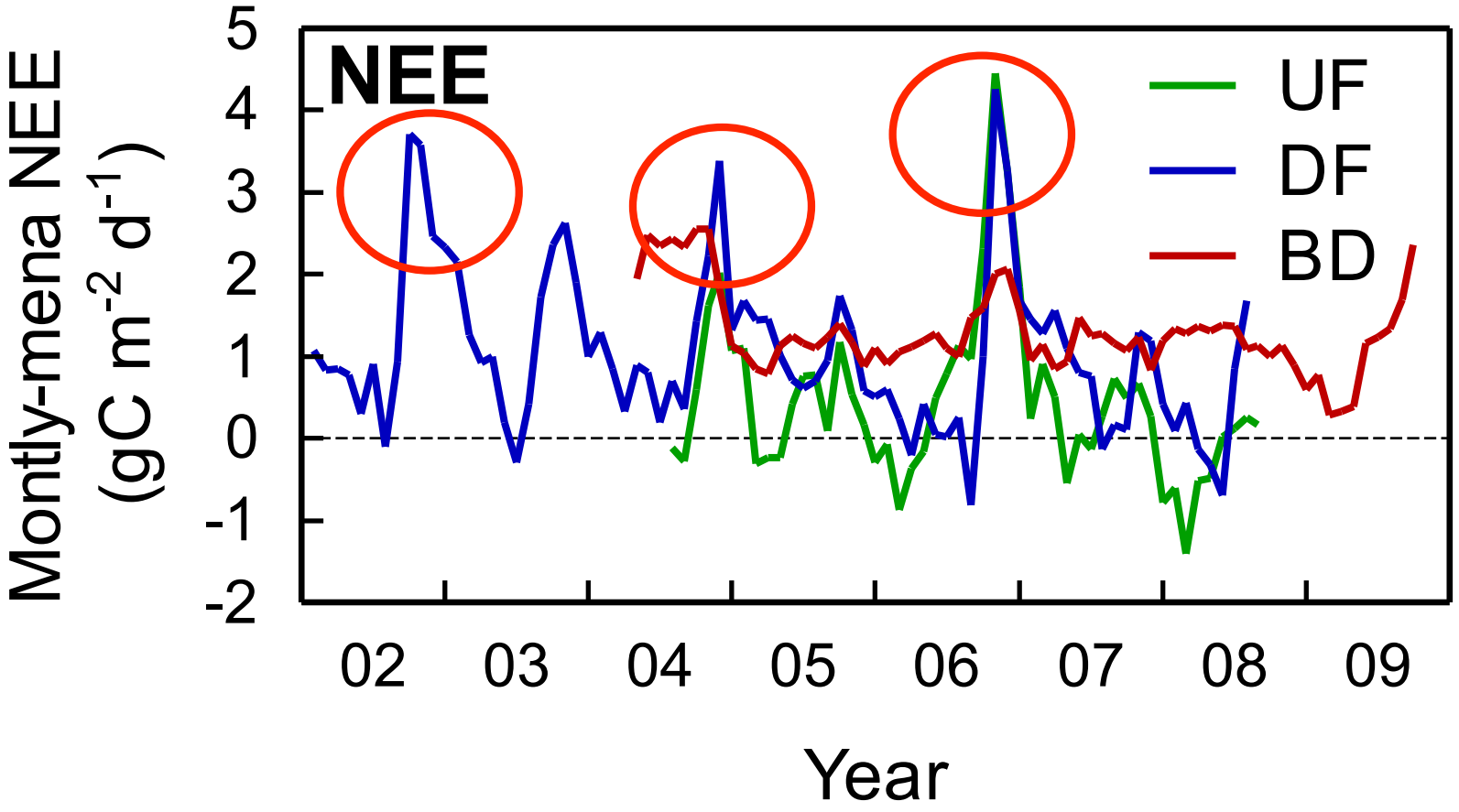
Integrated Monitoring-Sensing-Modeling (MSM) system:

Carbon Flux

Photo from Erianto Indra Putra (UNPAR)

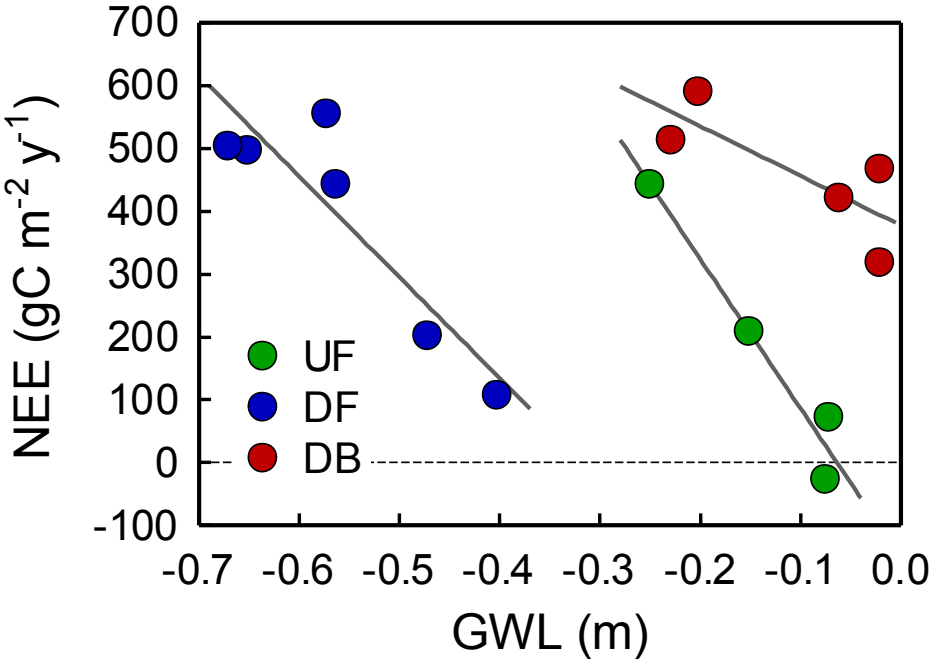
Seasonal variation in net CO_2 exchange (NEE)

NEE = RE - GPP



Large increases were found in the dry seasons of 2002, 2004 and 2006, El Niño years, because of shading by dense smoke and the enhancement of oxidative peat decomposition due to low GWL.

Annual NEE vs. annually mean GWL



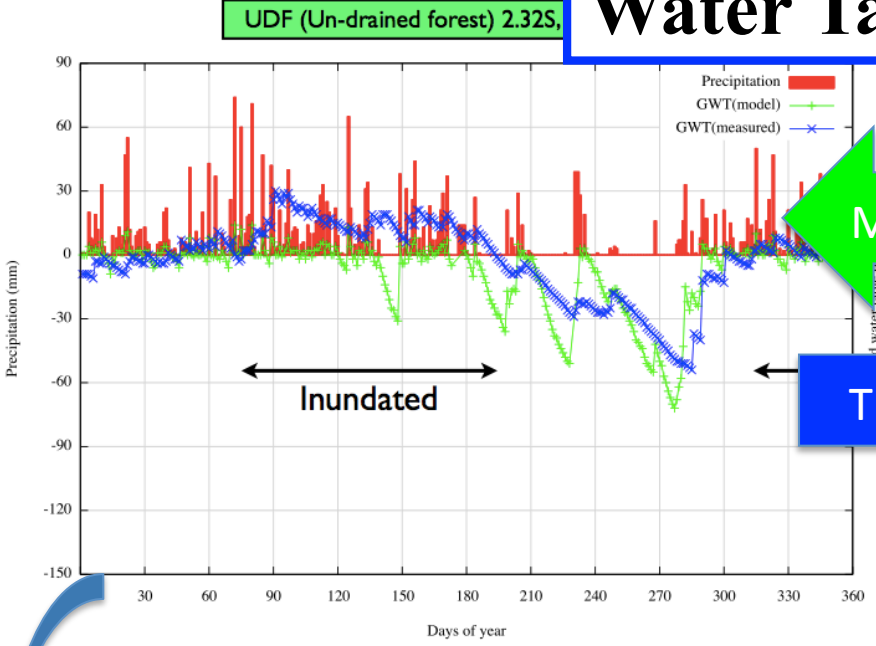
Hirano et al., 2012

A negative linear relationship for each site
→ Enhancement of oxidative peat decomposition under low GWL

Slope: UF > DF > DB → Undisturbed peatland is more sensitive.

Annually mean GWL is a robust indicator to assess annual CO_2 balance.

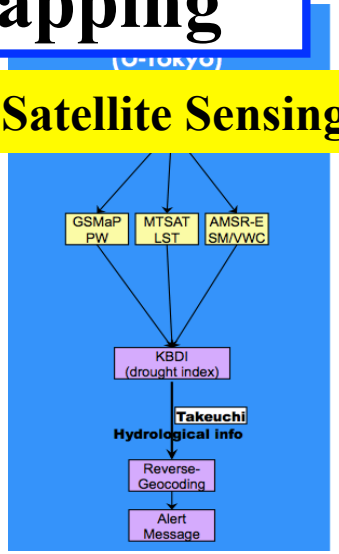
Water Table Mapping



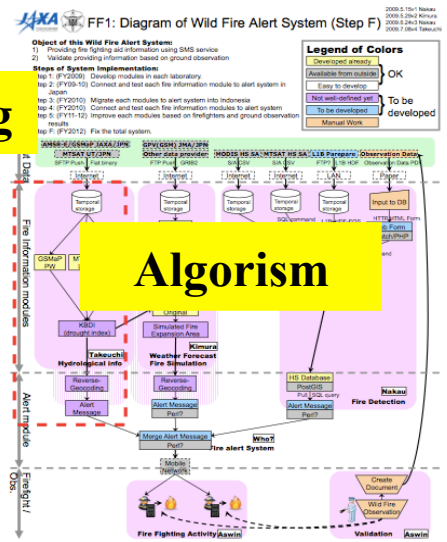
Modeling

Tuning

Satellite Sensing

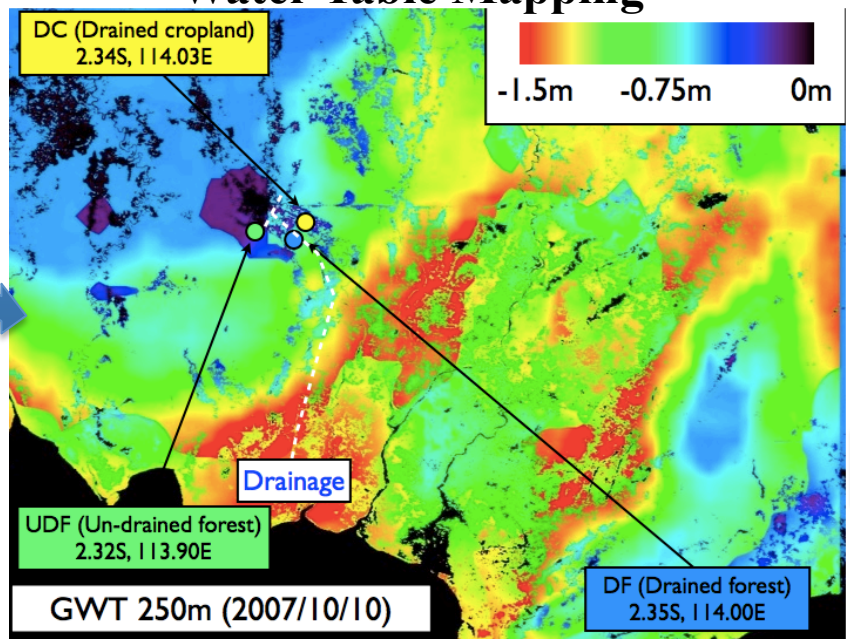


Algorism



By Wataru Takeuchi, University of Tokyo, Japan

Water Table Mapping



Input

Coefficiency between Water Table Level and

1) CO2 emission by Oxidation

2) CO2 emission by Fire Factors

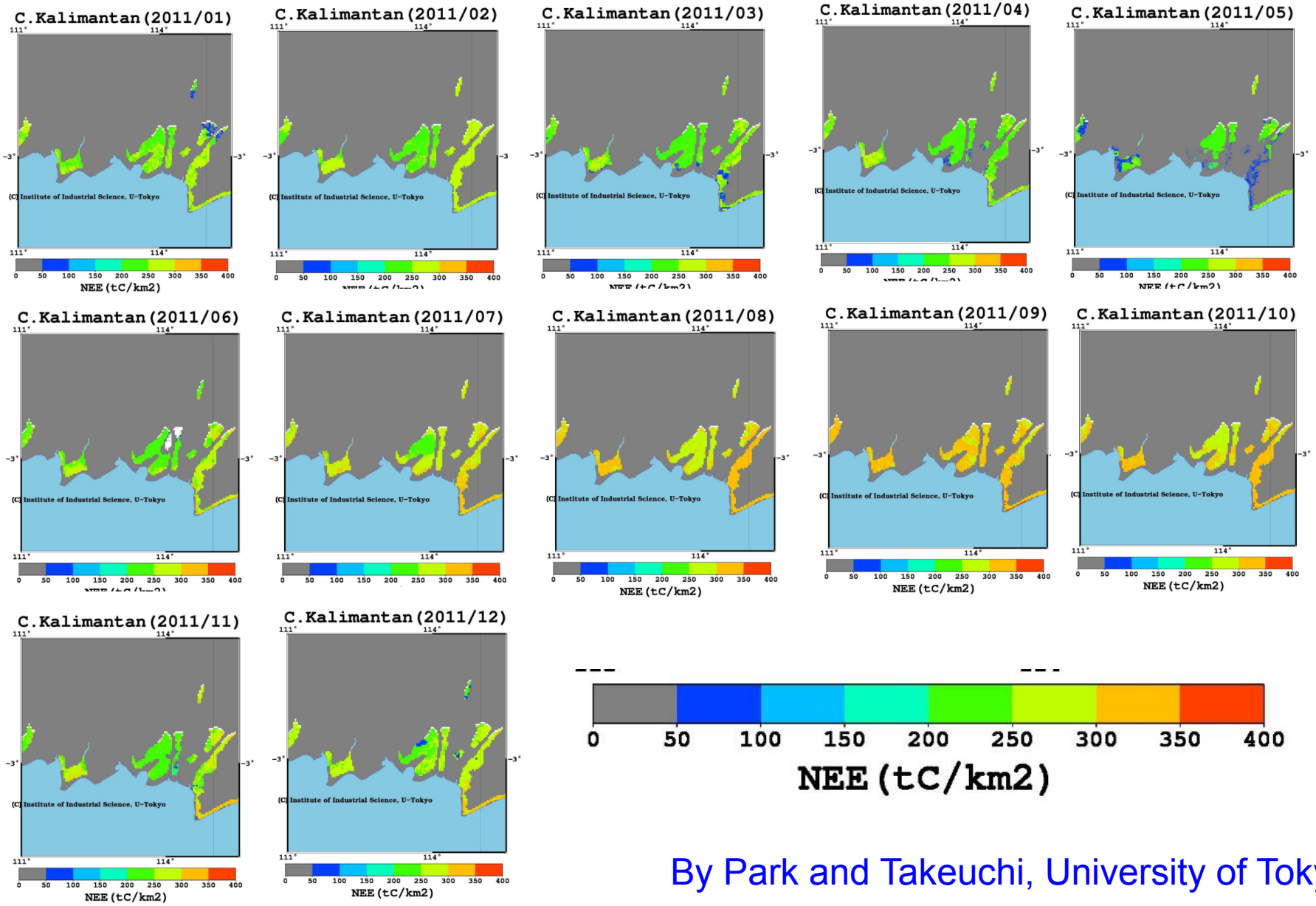
Output

Mapping of

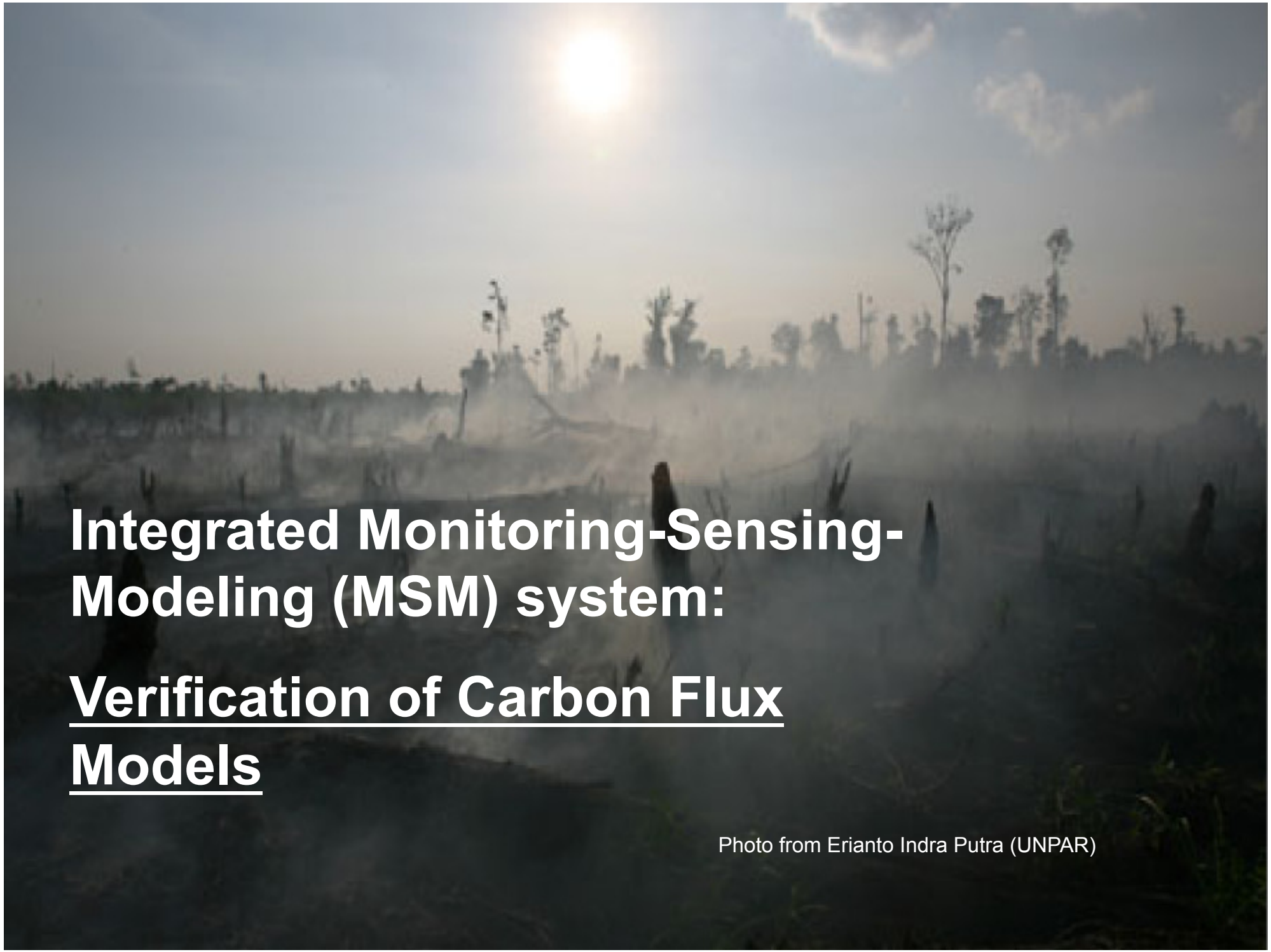
1) CO2 emission by Oxidation

2) CO2 emission by Fire Factors

CO_2 balance (NEE, tC m^{-2} $month^{-1}$) of peatland in Central Kalimantan in 2011



By Park and Takeuchi, University of Tokyo



Integrated Monitoring-Sensing-Modeling (MSM) system:

Verification of Carbon Flux Models

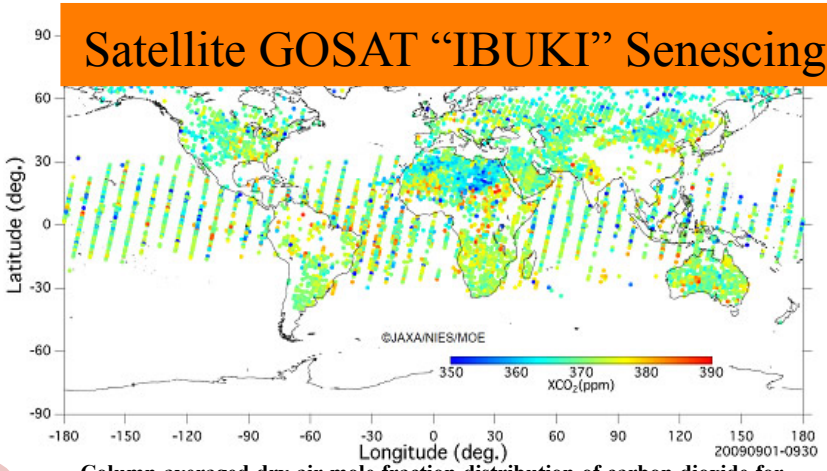
Photo from Erianto Indra Putra (UNPAR)

Top-down
- satellite
- airplane
- inverse model

Integrated, practical carbon budget map

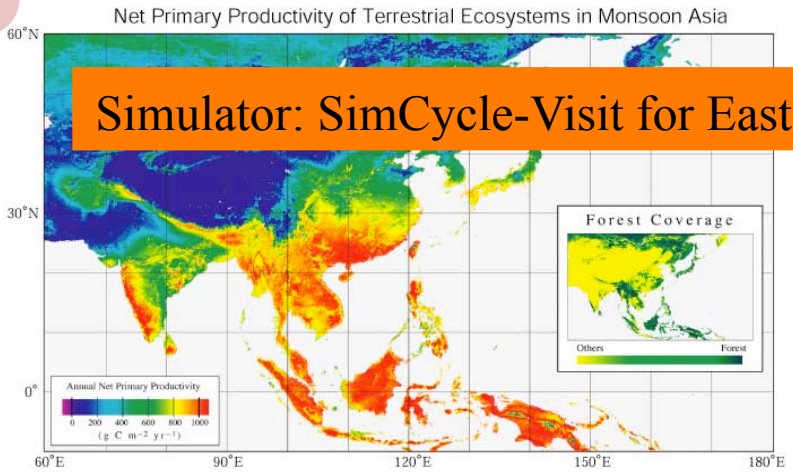
Bottom-up
- field survey
- flux obs.
- process model

Satellite GOSAT "IBUKI" Senescing: CO2



Column averaged dry air mole fraction distribution of carbon dioxide for the month of September, 2009, obtained from IBUKI observation data (unvalidated) By JAXA

Simulator: SimCycle-Visit for East Asia



Subsidence Model

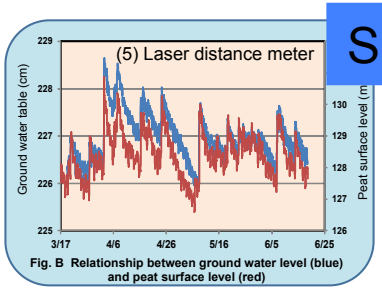
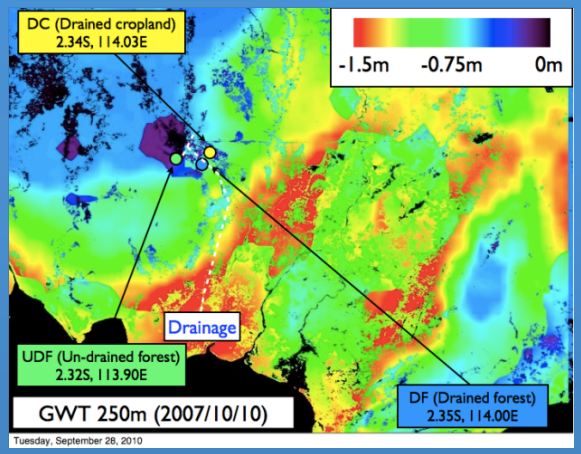


Fig. B Relationship between ground water level (blue) and peat surface level (red)

Presented by Kawasaki (2013)

Carbon-Water Simulation



- **Carbon Emission by Fire**
- **Carbon Loss through Water**
- **Carbon Emission by Microorganisms Degradation**
- **Tree Growth/Mortality**
- **Pest subsidence**

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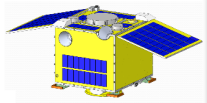
Inovation on Monitoring-Sensing-Modeling

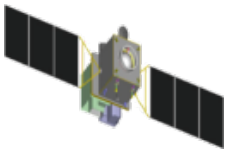
Hyperspectral Sensing by LCTF / HISUI

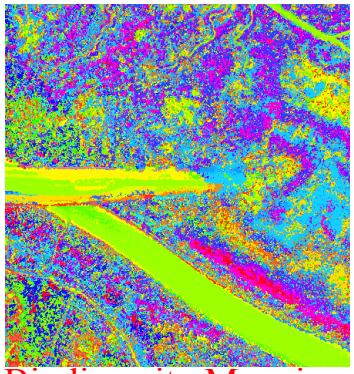


Micro Satellite

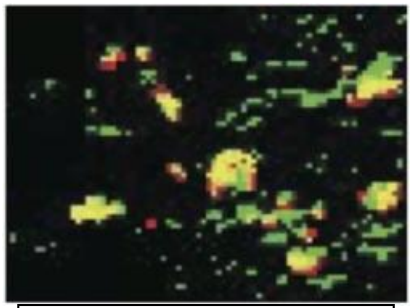
LCTF (2014～)
5 m resolution
@ 420~1050 nm, 630 band

HISUI (2016～)
30 m Spatial resolution
@ 10-12.5 nm, 185 bands

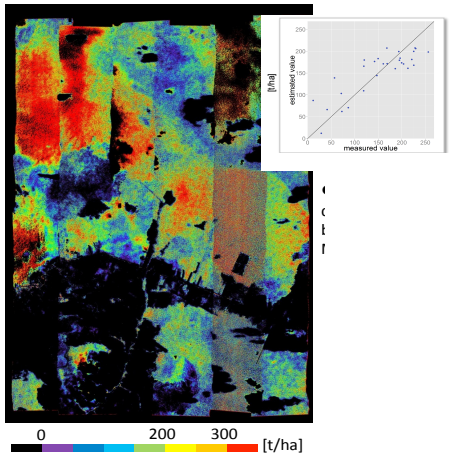




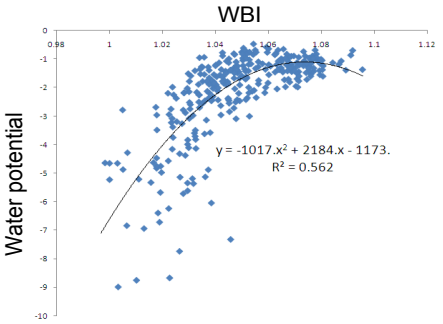
Biodiversity Mapping (one tree mapping) (Y. Takahashi et al)



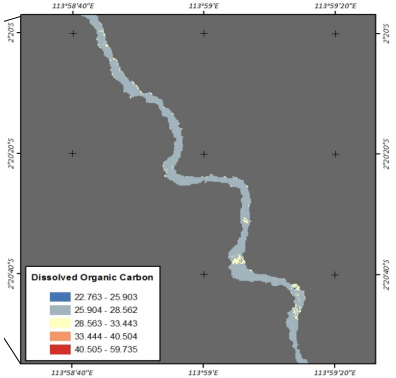
Forest Degradation Mapping (JSS & JAXA)



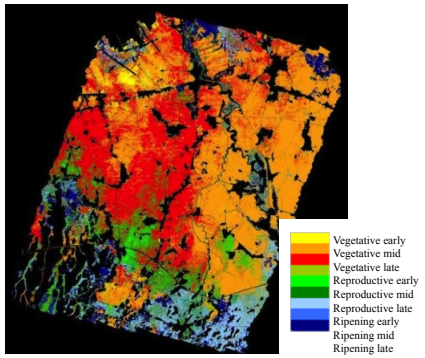
Biomass Mapping (JSS & JAXA)



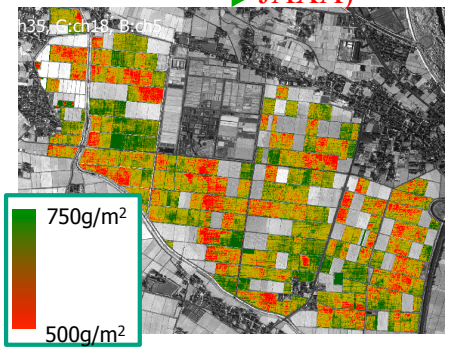
Leaf Water Potential Mapping (JSS & JAXA)



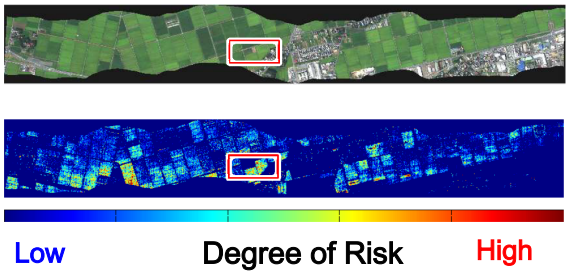
Dissolved Organic Carbon (DOC) Mapping (JSS & JAXA)



Crop Growth Stage Mapping (JSS & JAXA)



Crop Yield Mapping (JSS & JAXA)



Disease Mapping (Early detection of rice blast) (JSS & JAXA)

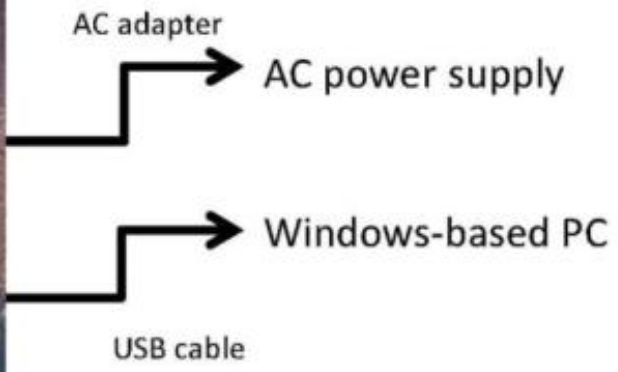
Toward global sustainability research – **Future Earth**

Thanks for your attention!

Field Campaign using High-Precision Telescope

AMI (Airborne Multispectral Imager)

LCTF (liquid crystal tunable filter-system)

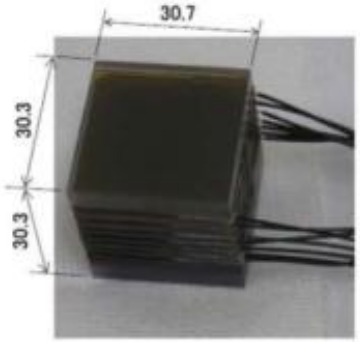


Multispectral Camera

- Wide FOV lens
- High-sensitive CCD
- Liquid Crystal Tunable Filter (LCTF) for Visible
- 190 x 100 x 100 mm
- 1.3 kg

Camera controller

- 100-240 V AC input
- USB 2.0 interface
- 300 x 200 x 60 mm
- 2.0 kg



LCTF

Specifications	
Wavelength range	420 - 700 nm
Band width (FWHM)	8 - 25 nm
Response time	< 0.3 sec
Frame rate	> 1 frame /sec
Number of pixels	659 x 494
Field of view	92 degree

Courtesy: Junichi Kurihara, HU

Smart Remote Sensing with Super-Constellation

Micro-satellite with LCTF (420-1050 nm: 630 band) in May, 2014

20 micro-satellites in equatorial orbits enables 5-min interval monitoring

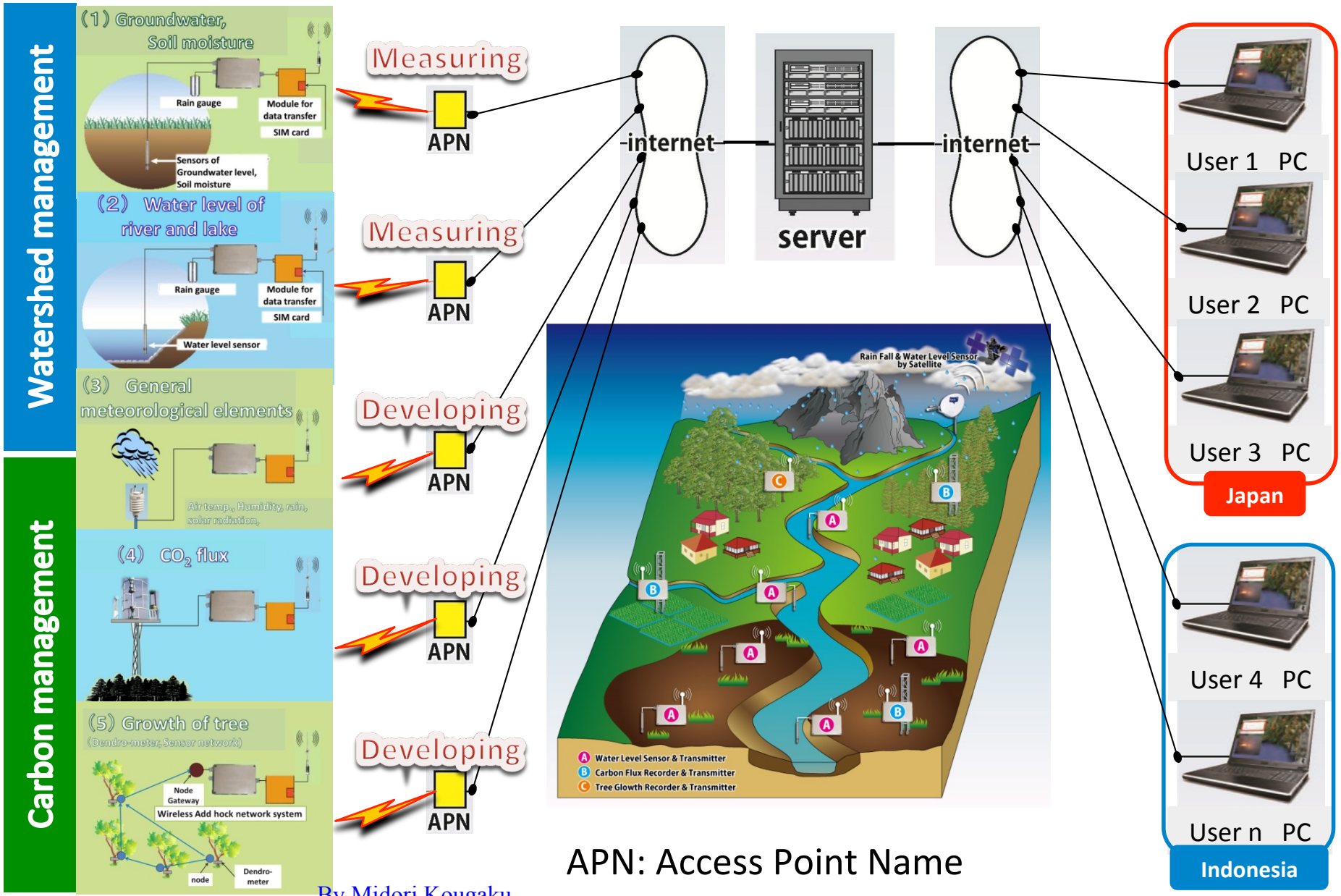
Short Term (Dynamic): Fire, Tsunami, Deforestation, Weather [20 micro-satellites]

Medium Term: Forest Degradation, Biodiversity Changing, Plant Growth, Water Pollution, LULUCF, GHGs Flux, Water Cycling [Modeling and Simulation][Several micro-satellites]

Long Term (Stable): Mineral Exploration, Biomass, Biodiversity, Village Mapping [Few micro-satellites]

by Yukihiro Takahashi

Land Monitoring: Information Collection using data transfer network of mobile phone



APN: Access Point Name

By Midori Kougaku